

- 1 -

FLEXOGRAPHIC SIMULATOR AND DIAGNOSTIC SYSTEM

This application claims the benefit of U.S. Provisional Application Ser. No. 60/180,163, filed February 4, 2000.

BACKGROUND OF THE INVENTION

5 1. Brief Description of the Invention:

The present invention relates to a computer simulation program for modeling a flexographic printing process. More specifically, the present invention relates to a series of computer program modules that simulate the operation and output of various flexographic printers through the use of formal database models based on materials and process information variables obtained through a user interface.

10 2. Field of the Invention:

Flexography is a complicated printing process using flexible "plates" to transpose an inked image onto different substrates. Ordinarily, years of training and experience are required in order to become proficient in operating flexographic printing presses. It would be desirable to provide a flexographic printing press simulator for purposes of training new operators, and for assisting skilled operators in diagnosing printing problems.

SUMMARY OF THE INVENTION

The present invention provides a flexographic printing simulator which gives the user "hands-on" experience in recognizing, analyzing, measuring and correcting production problems within the printing process. Complex process models and sophisticated display routines simulate the printing process and the resulting printed

product, allowing the user to see and correct the virtual product when things go wrong (or right) without incurring the time and expense of using an actual press.

There are several modules in the functional architecture:

- 5 1. A set of Data Bases (upstream of the actual programs) which contain a formal model of the process variables, their range of potential values, their potential interaction with each other and the effect their potential dysequilibria may have on the process output.
- 10 2. A User Interface which simulates a pressroom (several pressrooms are modeled), the printing and control systems in this pressroom. The interface lets a user verify and act on press and process parameters. These actions and verifications are communicated to the simulator, and produce various trace files for later examination. The user interface is structured to allow integration by the user of multimedia links so that video, text, photo, html files, etc. can all be hooked to any part of the simulated pressroom. This allows the users to personalize an otherwise
15 “generic” image.
- 20 3. A Simulator program which is a dynamic model of the printing process. It takes a predefined process state (correct or incorrect), propagates the information through the topological relations of the variables and, depending on the resulting values, may change the appearance of the simulated print copy. These changes of state may also result in messages or new values being displayed on the user interface or written into the trace files. The simulator architecture has been designed so that the computer interface (User Interface) can be replaced or supplemented by a direct connection to the press console (one step closer to a real “cockpit”).
- 25 4. A “Copy Desk” (so called because that is where a printer often spreads out the print to check its quality). A very complex set of software routines performs image manipulations in order to reproduce the “printed” effects on the copy. These can include changes in the size of the “dots” or in their “density” (the thickness of the

ink film), modifications to the substrate surface (wrinkling, creasing, tears), etc. This software also simulates a printer's diagnostic tools: densitometer, magnifier, spectrophotometer - giving the simulated values or providing the simulated magnification of the fault.

5 5. A "Trainer Module" allows a user to specify the sets of materials that they use, the "reference values" which give good results in production. The simulator then uses these values to define the "equilibrium" for the production run and any divergence from these values may (depending on its intensity) produce problem states in the simulated process and may result in "bad print". The user can also
10 define production costs which are then applied in the simulator so the trainees can track the economic consequences of their actions. The trainer module also permits the user to create problem sets which become the curriculum of a training course. The fact that the user can input their "production values" means that the trainee gets used to the "right numbers".

15 6. A "Copy Generator" allows users to enter their own images as simulated production jobs. This makes the training experience more real as the trainees are working with real-world print jobs - the same ones they see in their pressroom. This module analyzes the image and pre-calculates how certain faults would look if they were to appear on this image. For example, some faults are linked to areas of very
20 heavy color - these areas must be recognized and a set of faults (depending on the intensity of the fault which arrives) will be generated and stored for later use.

 7. A Diagnostic Help System. This system presents the databases in a way intended to help users troubleshoot print problems. This help system can run as a "standalone" product and can be embedded into production consoles and interfaced
25 with process control data. The data is structured in causal layers when viewed from the "fault" perspective. When viewed from the machine component perspective, the

data is presented as a component/subcomponent hierarchy, with each element in the hierarchy having a set of associated variables. Each of these variables is linked to its potential values and the print faults which may result if these values are not normative.

5 Other features and advantages of the present invention will become apparent from the following description of the invention which refers to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Fig. 1 illustrates an implementation of the flexographic simulator of the present invention provided on a computer system with two display monitors.

 Fig. 2 illustrates an implementation of the flexographic simulator integrated into a press control console simulator according to an embodiment of the present invention

15 Fig. 3 is a flowchart illustrating the overall flow of the flexographic printing simulator according to the present invention.

 Fig. 4 is a flowchart illustrating detailed steps in the operation of the flexographic printing simulator of the present invention.

 Fig. 5 is a flowchart illustrating the exit conditions for the flexographic printing simulator according to the present invention.

20 Fig. 6 is a flowchart illustrating the print display functions of a flexographic printing simulator according to the present invention.

 Fig. 7 is a flowchart illustrating print display inspection/quality control functions of a flexographic printing simulator according to the present invention.

25 Fig. 8 is a flowchart illustrating user interface routines of a flexographic printing simulator according to the present invention.

 Fig. 9 is a flowchart illustrating print image library functions of a

flexographic printing simulator according to the present invention.

Fig. 10 is a flowchart illustrating the production problem library functions of a flexographic printing simulator according to the present invention.

5 Fig. 11 illustrates a computer screen graphic for user configuration of a press selection in a flexographic printing simulator according to the present invention.

Fig. 12 illustrates a computer graphic model of a virtual flexographic common impression printing press simulated by the flexographic printing simulator according to the present invention.

10 Fig. 13 illustrates a computer screen graphic representing a virtual control console user interface for operating the simulated flexographic printing press of Fig. 12.

Fig. 14 illustrates a computer graphic model for a print unit and control panel in the common impression press of Fig. 12.

15 Fig. 15 illustrates a computer graphic model of an anilox roll mechanism within the print unit of Fig. 14.

Fig. 16 illustrates a press room view of a computer graphic model for an in line press according to the present invention.

Fig. 17 illustrates a computer graphic model of a control console user interface of the press model of Fig. 16.

20 Fig. 18 illustrates a press room view of a computer graphic model for a corrugated press according to the present invention.

Fig. 19 illustrates a computer graphic model of a control console user interface of the press model of Fig. 18.

25 Fig. 20 illustrates a training module interface screen for a flexographic printing simulator according to the present invention.

Fig. 21 illustrates a curriculum development screen for a flexographic printing simulator according to the present invention.

Fig. 22 illustrates a problem specification screen detailing process problems included in a simulated training exercise according to the present invention.

Fig. 23 illustrates a material editor user interface provided by a flexographic printing simulator according to the present invention.

5 Fig. 24 illustrates a press editor user interface according to the present invention.

Fig. 25 illustrates a predefined library of process problems for use with a flexographic press simulator according to the present invention.

10 Fig. 26 illustrates sample images from a print display module of a flexographic press simulator according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 illustrates a recommended configuration for invoking the flexographic printing simulator of the present invention on a computer system 2 equipped with desktop workstation 4 supporting dual monitors 6 and 8. A keyboard 10 and a mouse (not shown) typically are provided for user input and control. As shown in Fig. 1, the left hand monitor 6 displays a "pressroom user interface", and the right hand monitor 8 displays the "Print Display", as discussed in greater detail below. Typically, the computer system includes a multimedia PC with a special graphics card (e.g., MATROX 450 Twin head) that manages a dual-monitor display. The simulator also can run with only a single monitor, in which case the user would switch between the various available displays.

Fig. 2 illustrates an alternative implementation of the present invention, in which the simulators can also be integrated into a press control console 12. In this case the user "drives" a virtual (simulated) press from the normal console controls 14, with only occasional use of mouse 16. A keyboard 18 also is available for user input and control.

The flexographic simulator of the present invention can run on various computer systems as are known to those of skill in the art and generally available. For example, the simulator can run on a standalone industry standard personal laptop or desktop computer, or in a distributed environment over a local or wide area network. Recommended capabilities for the computer system include a Pentium®-grade or compatible central processing unit running at 200 MHz or higher, with 64 MB of RAM and a 2GB hard drive. A typical operating system would include Microsoft® Windows 95/98, for example. Also recommended are a Microsoft® compatible mouse, a CD Rom drive, a diskette drive, sound card and speakers, and a video graphics card and monitor(s) as required by the type of configuration to be implemented. In addition, access to the Internet and an Internet browser are recommended to enable downloading of software revisions and upgrades, for example.

The flowchart of Fig. 3 illustrates the overall organization of the flexographic printing simulator computer program of the present invention. Initially, a Launch Screen is presented to a user, and from there the user can begin configuring the software application by selecting an initial press type in block 22. A typical software configuration screen is shown in Fig. 11. Configuration options include a Common Impression (CI) press, a Corrugated Stock (CS) press, and an In Line (IL) press. These and other options will be explained in further detail below. Once the initial press type is selected, the user has a choice of modes at block 24, such as Standard operating mode or a Problem-Solving mode. In the standard mode, the simulator loads a selected set of values and images at block 26 from library databases 28, 30 into the simulator for execution. In the Problem-Solving mode, training exercises choices are available 32 to be loaded 34 from libraries of print images 36 and production problems 38, challenging the user to correct the problems by adjusting various operating parameters. An example of a predefined process problem selection

screen is shown in Fig. 25. Once the selected mode has been established, the simulator is initialized with starting values **40** and the simulator runs **42**. Upon satisfying required exit conditions **44**, the session files are closed and the simulator returns to the Launch Screen **20**.

5 Fig. 4 is a flowchart showing in greater detail the steps involved in running the simulation at block **42** of Fig. 3. The system initially propagates new process values **48**, and checks for process disparities and imbalances **50**. The diagnostic help system is updated **52** with the new information, as well as the process and display values **54**. The resulting print images are generated and sent to Print Display and
10 Inspection **56**. Updated values for Press and Pressroom routines **58** are sent to the User Pressroom Interface **60**. A record is kept of each session **62** to provide a trace **64** of the process for diagnostic and learning purposes. Values updated through the user Pressroom Interface **60** are obtained at block **66**, as necessary, and a simulation is performed **68**.

15 An exit routine for the program is illustrated in the flow chart of Fig. 5. The user can request termination of the simulation **70** in which case the session files are closed and the program exits at block **46**. Otherwise, a Problem Solving determination is made as to whether the current set of production problems has been resolved **72**, in which case either a predefined problem set **74** will continue to run **76**,
20 **78**, or the program will exit **46**.

 Various print display functions and options are shown in Fig. 6. Once the simulated print image has been calculated **80**, print display functions are available at block **82**. The color plane and materials surface information is updated to include any faults that are determined to have occurred. All color planes and surface
25 information are then recombined to provide the simulated "printed copy." The user can opt to view the full image, or only parts of the image, which can be updated automatically or on-demand. In addition, images at any point in the processing

sequence can be obtained, and a “proof” can be displayed and compared side-by-side with the current print.

Fig. 7 details various functions that are provided to assist in quality control inspection of the simulated print 84. For example, a simulated magnifier can be used for closer inspection of print dots, and a simulated spectrophotometer is used to measure CIE L*A*B* and Delta E values. (CIE = Commission Internationale de l’Eclairage: The International Commission on Illumination.) Comparisons also can be made using control strips. In addition, simulated VOC (volatile organic components) readings can be obtained, and a simulated “tape test” can be conducted to measure adhesion. A virtual densitometer also is provided to measure density, dot grain, and trapping. Histories of quality control inspections are archived in the session files 76.

Referring to Fig. 8, preferred user interface 60 routines include control panel interactions for each of the different press types. Available control functions include speeds, temperatures, tension, pressures, and ink values, among others. As discussed further below, user interaction and control also is available for pressroom components and subcomponents. Included in the data supplied and retrieved are economic variables, such as cost and time information. The user also can custom annotate the program by adding multimedia links.

Referring to Fig. 9, a set of standard print jobs is available. These have already been pretreated by the Print Job Generator and are ready for use by the Display routines in the simulator. Optionally, a print image can be entered for analysis 94 using a graphics program such as PhotoShop, for example. The program also will precalculate potential print faults for each color and each level of fault intensity. Control strips and register marks also can be added to each print job. A description of the print job is added to a Production Problem Library 96. The precalculated print faults and proof images having no faults are indexed 98 and

stored in a Print Image Library **100**.

The Production Problem Library **102** can be used to establish press specification **104**, create training curricula **106**, and to determine materials for production **108**, as illustrated in Fig. 10. A trainer module, discussed further below, also can access the production problem library through these services.

Referring to Fig. 11, an initial computer screen **110** for configuring the simulation software is shown. Configuration options available to the user include the type of press **112**, the number of screens **114**, sound **116** and language **118**. From this panel, the user can also access Trainer functions to specify and modify the library of production problems.

Proceeding from the initial launch screen **110**, the simulation program generates an interactive virtual pressroom view of the type of press chosen. Fig. 12 illustrates the Common Impression Press (CI) Pressroom view **120**. The press room is shown in perspective, and each functional component of the press **122** can be interactively accessed by the user in order to verify and adjust settings, or to check and repair mechanical or electrical malfunctions. In Fig. 12, for example, Unwind panel **124** is highlighted for selection of controls specific to its operation. In addition, a control console **126** shown to the right of press **122** lets the user simulate all the normal press operations. Navigational control icons **128** are provided at the bottom of the screen.

Figs. 13-15 illustrate selected representative portions of the control console, print units and, in more detail, a subcomponent of the print unit, an anilox roll assembly, respectively. Although specific mechanical components are shown only for the CI press, they are present for other press types and are represented by the simulation program in the same general manner.

Referring more specifically to Fig. 13, a portion of a Control Console User Interface **130** for the control panel **126** of CI Press **122** is shown. This representative

part of the control console illustrates virtual controls **132** for adjusting tension of the substrate as it moves through the press. The console also offers control and data readouts **134** of speed, temperature, pressure, job ticket information, and all the other parameters found on a modern console for a CI flexographic press. Other available control options can be selected from panel **136** at the bottom of the screen. Supplementary control icons **138** provide access to help information and program navigation, for example. An elevation view **139** of the CI press provides a reference regarding the materials paths (reading left to right) through the press, which is echoed in the sequence placement of the tension controls on the screen (unwind to rewind).

Fig. 14 illustrates a two panel representation of mechanical component modeling specifically with respect to a Print Unit of the CI press. A press component panel **140** is shown to the right of Fig. 14, alongside the unit control panel **142** on the left. The control panel includes groups of icons arranged for press speed adjustment **144** including Start, Stop, Run, and Jog; a choice of print units (from 1-8) **146**, showing the color being printed **148** (e.g., yellow on unit 1); pressure adjustments for ink transfer group (current print unit) **150**; and selective control **152** of Doctor Blade/Anilox Roll, Anilox Roll/Plate Cylinder, and Plate Cylinder/Impression Cylinder. Pressure can be adjusted at either end of each component, or globally for the component. Lateral and Circumferential Register adjustments (current print unit) also are provided. In press component panel **140**, a subcomponent anilox panel **154** is highlighted for selection and control as discussed in connection with Fig. 15.

Fig. 15 is a two screen representation of the anilox roll control and component screens as linked from the Print Unit of Fig. 14. The anilox roll mechanism itself has further subcomponents such as shafts, seals, etc. (not shown) that can be accessed from the component screen **156** shown on the right of Fig. 15 to provide detailed virtual control of the selected press. Menu control screen **158** is

shown on the left. The icons in the upper portion of the anilox roll component screen **156** allow the user to choose which type of information or action they wish to display or modify using the control screen **158**. Accordingly, the user can set values **160** (the current choice), visually control the state of the component **162**, or take other measures. Graphical representations of the anilox roll include a detailed view **164**, a perspective view **166**, and an end view **168**.

The control screen **158** shows a menu of the process variables (the subset available to the user) related to this component, with current value and an indication whether or not the current value matches the recommended production value. The cost and time fields **170** at the bottom of the menu screen are used to inform the user of the time and out-of-pocket cost of verifications or actions used to solve production problems. Thus, the user can calculate the virtual production cost for the session. Both screens also include various additional icons for program navigation and control.

Referring to Fig. 16, a pressroom view **172** of an IL (In Line) press is shown according to the present invention. IL (also called "narrow web") presses are used for printing labels or folded cartons. Similar to the CI press described above, virtual IL press **174** and control console **176** are shown in an interactive, perspective view interface after selection of the IL press from initial launch screen **110** shown in Fig. 11.

An example of a control screen interface that is accessible from IL press control console **176** is shown in Fig. 17, in which a view of the Impression control panel **178** has been selected by the user. An array of virtual control icons is presented that are specifically adapted for control of the virtual IL press **174**.

Fig. 18 illustrates a virtual CS (Corrugated Sheet) pressroom **180**. Corrugated sheet presses generally are used to print corrugated boxes. The pressroom view again includes an interactive perspective view of a CS press **182** and

a control console **184**. A print panel is highlighted for selection. A control screen **186** for the CS press is shown in Fig. 19, a board transfer control panel having been selected by the user.

5 An interface screen **188** that provides access to the trainer module of the present invention is shown in Fig. 20. The trainer module lets the user specify and modify the production problem library discussed above in connection with Figs. 3 and 10. The production problem library covers the way the press and materials are chosen. It also includes the training exercises that make up a curriculum. From the Trainer module screen **188**, it also is possible to access the session files
10 which record how each user has done when trying to solve the simulated production problems.

Referring to Fig. 21, an example is shown of training exercise screen **190** in which a process problem to be included in a sequential problem set is presented. Screen **190** is one part of a curriculum development module of the simulator. The
15 Press Situation List **192** on the left of the screen contains definitions of potential process problems. The trainer chooses which of these will be included in the current set of Sequential Situations **194** being defined. Once the set of problems has been defined, the set will be given a name and stored in the Production Problem Library. It is thus possible to make problem sets in a range of difficulty, from simple to
20 complex.

Fig. 22 illustrates a situation screen **196** showing details of how problems in a run specification will effect parameters of the simulated press. The screen image shows the details of one of the process problems being included in a training exercise. Illustrated are values for initial process variables (Core Holder Roll Secure,
25 and Web Guide Activating) that will be initialized as being incorrect. This will cause problems with the process which will be visible on the process output (the printed product).

Referring to Fig. 23, a materials editor screen **198** is shown whereby the user can specify various types and values of pressroom materials for use in the simulated pressroom. Using the materials editor, different production sites can adapt the simulator to reflect their "best practice."

5 Further parameters are set using the customer specifications screen **200** shown in Fig. 24, which accepts values for each color printed in each graphic separation layer. Users can set up the virtual presses for the simulated production run in the same manner as they prepare presses for real production. For each print unit the user decides what materials will be used. The wrong choices - or choices of
10 incompatible materials - will cause process problems.

Once problem sets have been defined, they are placed in a library. Users can access the appropriate problem set from the library using an access screen **202** shown in Fig. 25. The library structure includes Packages, Courses, and Exercises. Packages (e.g., for CI presses) contain different Courses; Courses contain exercises.
15 Each course focuses on a different subject; and the exercises contain many different process problems. The user is expected (but not obliged) to enter their name so the session can be evaluated at a later date.

Fig. 26 illustrates sample images from a print display module. On the right of Fig. 26 is a "proof" image **204**; the left-hand side shows a current print **206**. The
20 proof differs from the current print as the result of too little pressure on the yellow plate cylinder, which is revealed by a flaw in coloring of the words "PREMIER EDITION." As the process conditions are modified the print images generated by the simulator are modified in real time. The images can be inspected and measured with simulated analysis tools such as densitometers, spectrophotometers, magnifiers,
25 etc. The measurements from the proof are compared to those from the print in an effort to analyze the potential problem and its causes.

Although the present invention has been described in relation to particular

embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art. It is preferred, therefore, that the present invention be limited not by the specific disclosure herein, but only by the appended claims.

It is further stated that the present invention is not limited to the specific disclosure herein, but only by the appended claims.